CFAST – The Fire Model in the SQA Toolbox for Safety Analysis

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Washington Group International
Integrated Engineering, Construction, and Management Solutions

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Software QA for Safety-Related Software

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- DNFSB TECH-25
  - Issued in January 2000
  - Concluded that SQA for safety analysis software is incomplete
- Recommendation 2002-1
  - Issued September 2002
  - Define Responsibility & Authority
  - Recommend Software
  - Update Directives
  - Conduct Research & Development

Toolbox Codes to support DSA work

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- Selected Software
  - Fire — CFAST
  - Leak Path Factor — MELCOR
  - Chemical Release/Dispersion and Consequences — ALOHA, EPIcode
  - Radiological Dispersion and Consequences — MACCS2, GENII.
- Document Access
  - http://tis.eh.doe.gov/sqa/central_registry.htm
  - Interim guidance reports are issued
  - Interim gap analysis reports are issued

Zone Model Basics

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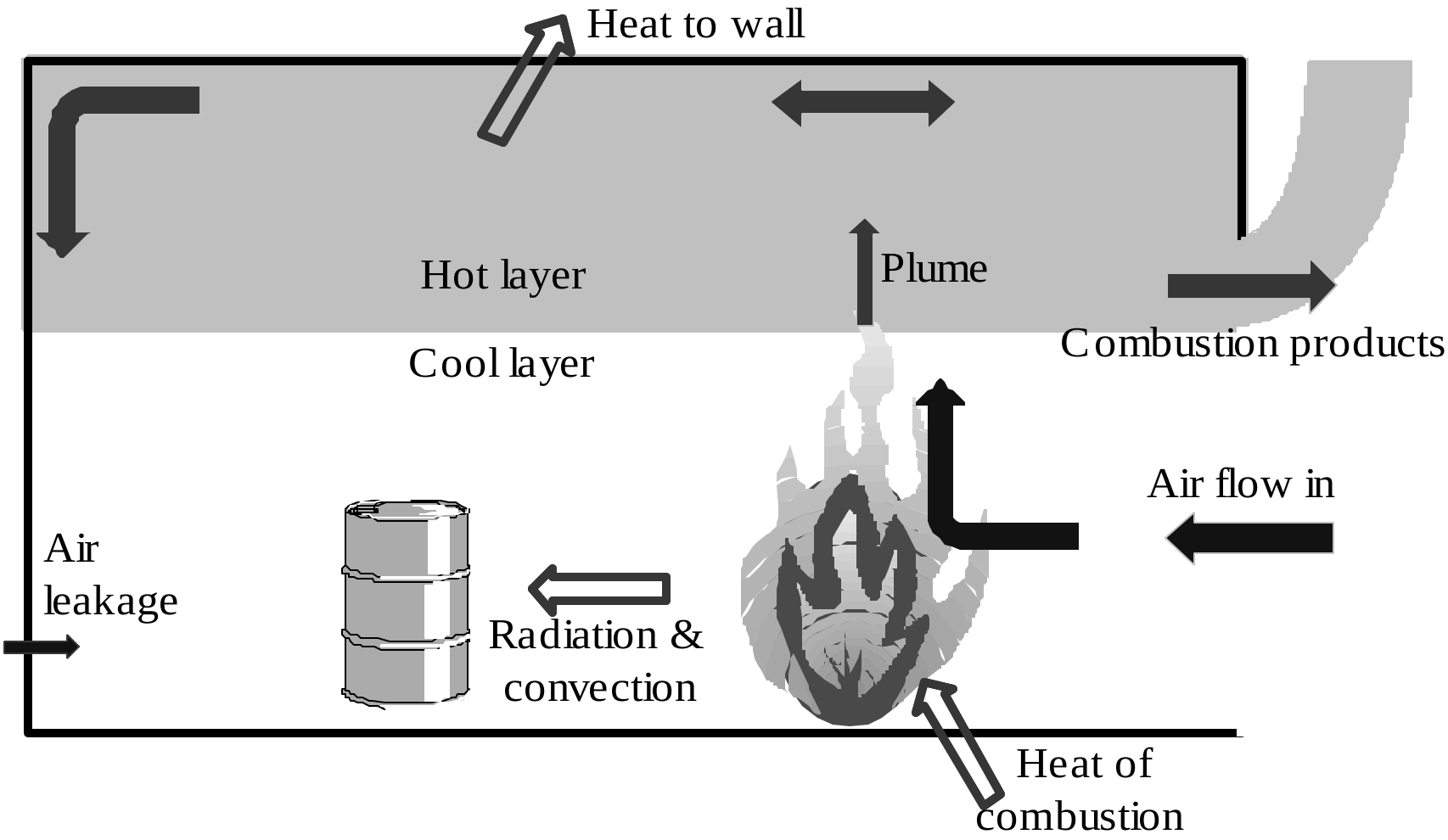

CFAST Design

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- CFAST is a zone model
- Solves Navier-Stokes equations for mass & energy transport
- Separates a fire compartment into two layers
- Each zone is assumed to be uniform (temperature, smoke concentrations, etc.)
- Fire acts as a pump - moves energy and mass between layers - other mixing occurs at doors

Typical CFAST Results

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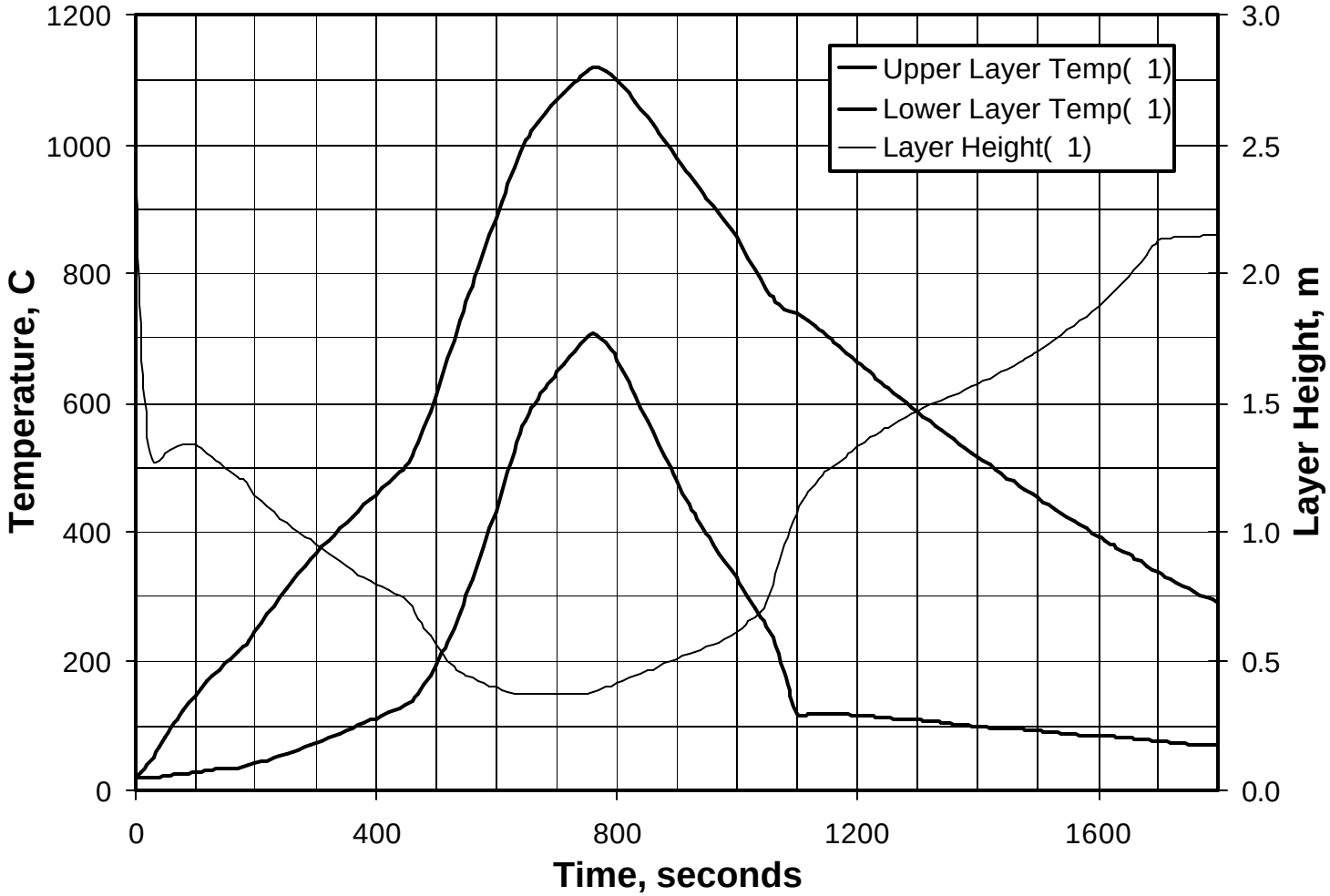

Capabilities

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- Accounts for effect of oxygen depletion
- Tracks O_2, CO_2, CO, Soot, HCl, HCN
- Handles 30 fire compartments
- Main and object fires
- Models
  - Natural convection
  - Force convection
  - Changes in horizontal openings

Principle Limitations

- CFAST does not evaluate fire behavior, rather it models the response of the building to a fire
- Neglects
  - Radiation feedback from walls that would increase pyrolysis rate
  - Wall flow
  - Radiation transfer through openings

Available CFAST Versions

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- Two actively supported versions
  - Version 3.1.7, published October 2001
  - Version 5.1.1, published May 2004
- Graphical User Interface (GUI)
  - Version 3.1.7 – works for most versions of DOS (95, 98, 2000, ME)
  - Version 5.0 – not ready for prime time

HRR and Pyrolysis Rate – 3 Trash Bags

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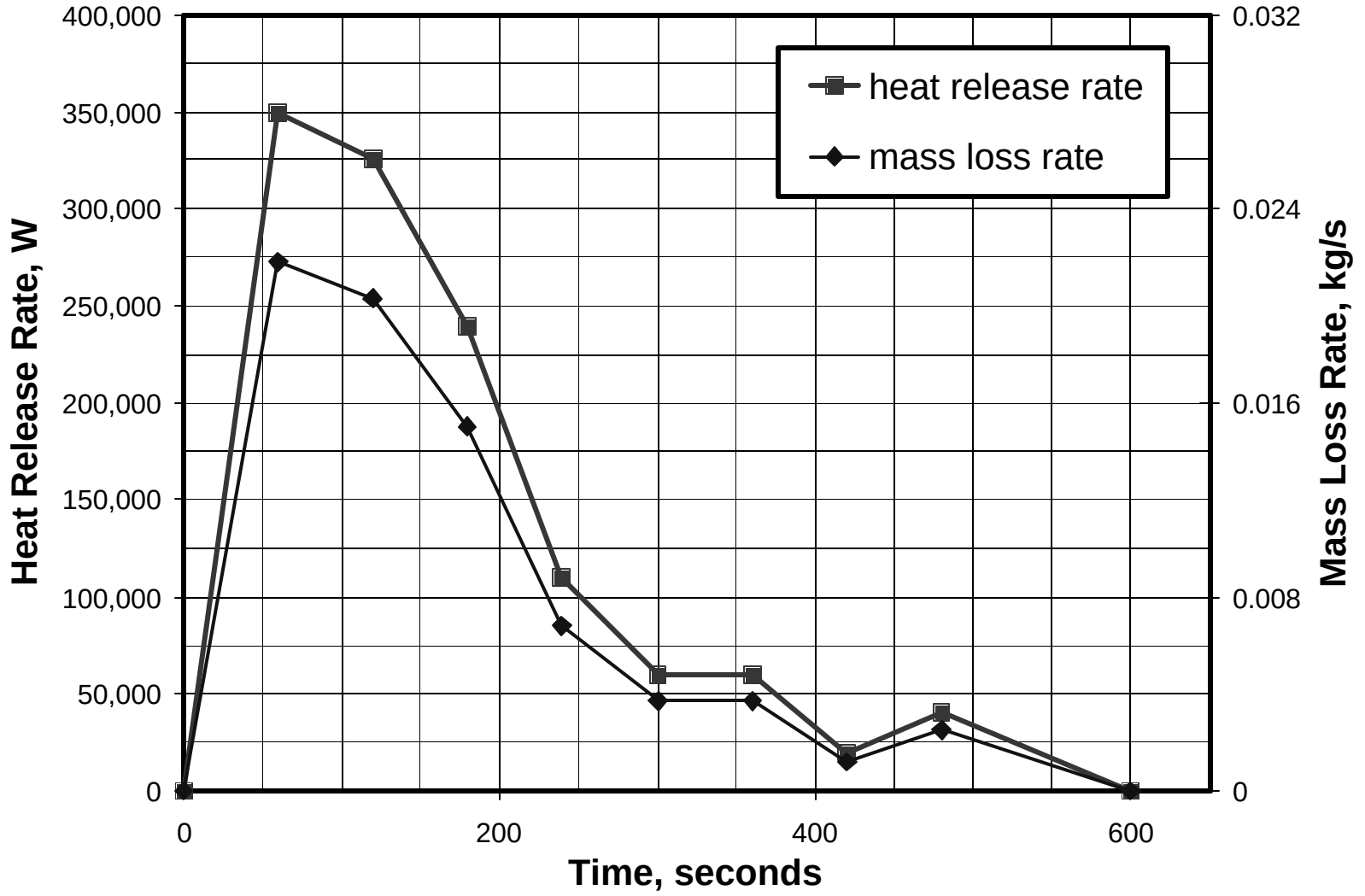

CFAST Libraries & Output

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- Libraries
  - Thermal Properties Database (thermal.df)
  - Object library file (objects.df)
- Output files
  - History file *.HI
  - Text file (Echo file) *.txt
  - Spreadsheet file *.csv
- Other topics
  - CPLOT
  - Graphical User Interface (GUI)

Graphical User Interface (GUI)

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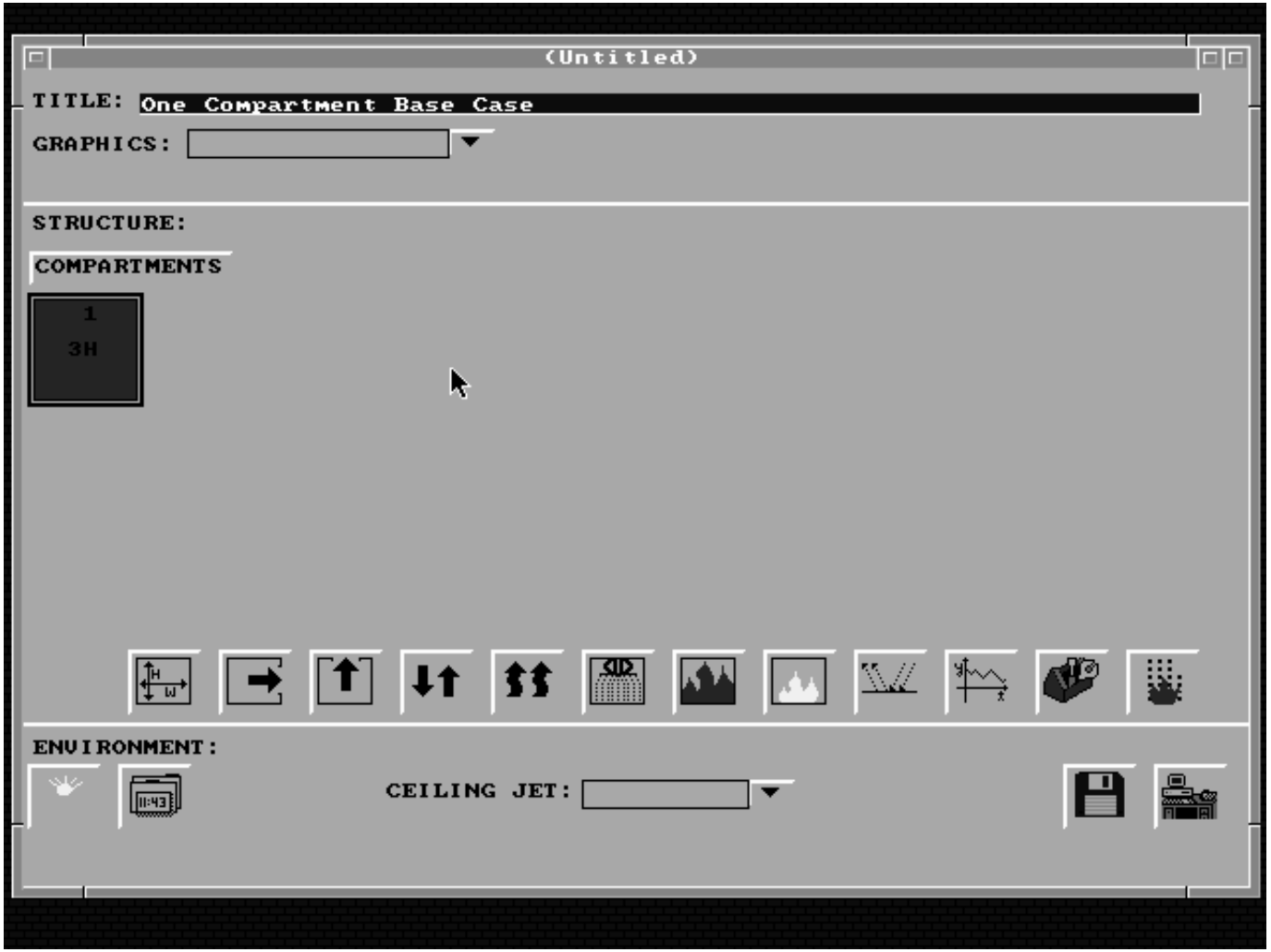
- Permits the automatic generation of the input file
- Is menu driven
- Automatically generates HRR and pyrolysis curves
- Supports modification of thermal library files
- Supports modification of object library files
- Allows pictorial development of mechanical ventilation systems
- Provides estimating tools derived from FIREFORM

Graphical User Interface – Basic Screen



DOS – CFAST Command Line

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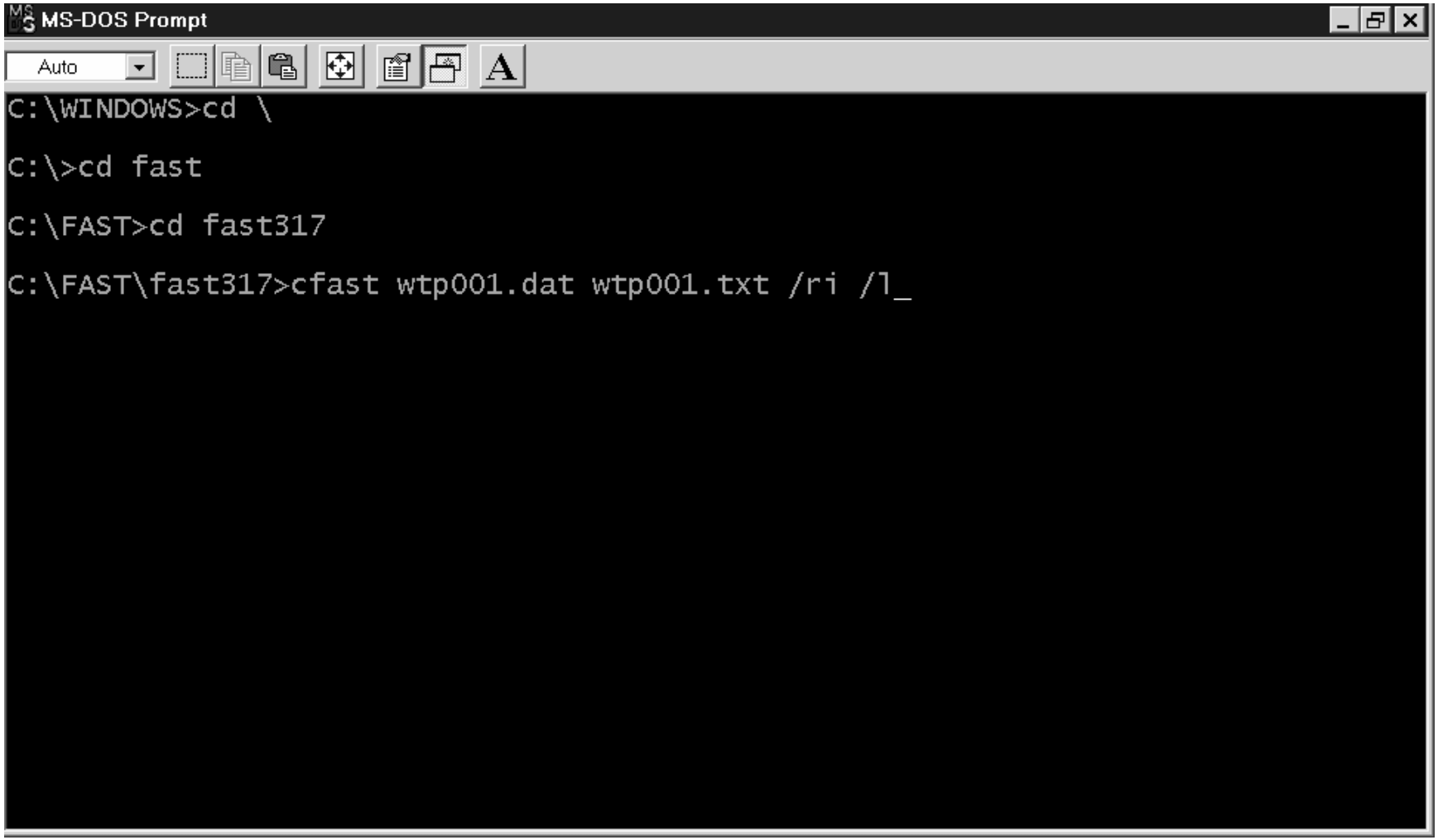

Possible CFAST Analytical Approach

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- Must address:
  - Analysis uncertainties
  - Facility variability
  - Establish a reasonable degree of analysis margin
- Solution Method
  - Run multiple scenarios
  - Focus on defending design, not obtaining the most accurate representation of a single fire scenario
  - Analysis must consider all potential scenarios

CFAST Analytical Steps

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1. Use most likely ventilation conditions & geometry
2. Use a reasonably bounding (nominal) HRR curve
3. Establish the room temperature profile w/CFAST
4. Iterate the ventilation conditions & geometry to maximize temperature
5. Iterate the HRR curve (50% increase in PHRR)
6. Iterate the HRR curve (80% of nominal PHRR)
7. Report the most demanding time-temperature profiles developed above as sufficiently bounding temperature profiles.

Addressing Flashover Potential

- Not expected if $T_{upper} < 450°C$.
- Expected if $T_{upper} > 600°C$
- Indeterminate if $450 < T_{upper} < 600°C$
- If indeterminate:
  - Increase HRR curve slightly (i.e., total energy 2X)
  - T < 600°C, nominal HRR temperature curve is considered representative.
  - T > 600°C: take temperature to be 600°C

Project Plan for CFAST Effort

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(1) Establish inputs (HRR curves, combustion chemistry estimates, room geometry, etc.) with an appropriate citation

(2) Conduct CFAST modeling (consider benchmarking to similar problem)

(3) Produce sensitivity and switchover analysis

(4) Document analysis

Conclusion

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- CFAST can be used to support DSA preparation
- Users must be knowledge in fire modeling & understand implications of assumptions
- Consider benchmarking results
- Establish consistent analytical approach
- Running the model is only part of the effort